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Final Draft of Literature Review

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**Statement of the Problem**

International mathematics assessments indicate that United States students consistently rank far behind their peers in similarly developed countries. Scores on the National Assessment of Educational Progress, or NAEP, demonstrate that far too few U.S. students are at or above the proficient level in math and science (Epstein & Miller, 2011). New techniques that flout tried and true math teaching methods are a key source of the disparity. Education reformers, representing the education establishment, believe the learning "process" is more important than memorizing core knowledge. They see self-discovery as more important than getting the right answer. Traditionalists, consisting mainly of parent groups and mathematicians, advocate teaching the traditional algorithms. They advocate clear, concrete standards based on actually solving math problems. The destination - getting the right answer - is important to traditionalists.

The textbook that has become the gold standard for reformers is called *Everyday Math*. It is deeply flawed in its approach. Researchers have found that it does not teach addition with regrouping and instead uses cumbersome, time-consuming, less efficient, more laborious, non-standard "partial sums" method. It also discourages the practice of standard algorithms for multiplication and division. Here too it incorporates cumbersome, time-consuming, less efficient, more laborious, unduly complicated "extended facts," "partial products," and "lattice" methods. A formal introduction to division algorithms is not included and crutches (e.g., counters, arrays, drawings) in division are never dropped.

**Standards-based/Reform/Constructivist Math Curricula**

Overview of Reform Math

Herrera & Owens (2001), note that the most recent movement to revolutionize math teaching in the United States is NCTM Standards-based reform. The reform Standards do not list specific topics to be covered by the end of each grade. Instead, guidelines are provided with examples intended to present a unique conception of math content. One of the benefits of the movement is the push to make concrete connections between mathematics and the real world paramount. There is also more of an emphasis on higher order processing through problem solving, communication, and reasoning. The shift from direct, algorithm-based instruction to Standards-based reform is underpinned by a new emphasis on constructivism and conceptual knowledge over procedural knowledge. In the past, the primary mathematics computation in early school years was based on the pen and paper algorithm (Varol & Farran, 2007). However, modern reformers now realize the importance of mental computation.

Reform mathematics is also known as research-based mathematics because its policies are largely aimed at ensuring that efforts to reform math education are rooted in current and high-quality scientific knowledge about what content students should learn, how they should learn such content, and how they should be assessed (Superfine, Kelso, & Beal, 2010). Whereas many see the reforms as merely a fad, advocates of the movement look for data to back up proposed changes. Fortunately, these changes have been around long enough to be empirically evaluated (see “Field Testing” below).

Reform Instructional Methods

Fraivillig, Murphy, & Fuson, (1999) conducted a case study of first grade teacher, Ms. Smith’s, use of the reform text, *Everyday Math*. Her successful strategies included eliciting students’ solution strategies, facilitating their responses, supporting conceptual understanding, and extending mathematical thinking. She encouraged students not to worry about answers per se, but instead to collaborate and explore various problem-solving tactics. This behavior was consistent with Moyer, Cai, Wang, & Nie, (2011) study that found about twice as many reform lessons as traditional lessons are structured to use group work as a method of instruction.

This is advantageous to students because teachers whose goal it is to foster their students’ interests are more likely to use cooperative activities in math (Durik & Eccles, 2006).

Ma & Singer-Gabella (2011) analyzed routines in reform classes. According to the researchers, a typical teacher script in a reform classroom might be as follows:

*“I would like for you to solve this problem today in as many ways as you can come up with. I will give you a few minutes to think about it. You can talk with other people if you would like and then we will look at some of the methods by which you’ve solved the problem. A book has 64 pages; you’ve read 37 of those pages, how many pages do you have left to read? Be sure that for any method you use that you can explain how you did it in terms of quantity of pages. Come up with as many ways of solving it as you can.”*

Reform Theorists/Practitioners

The standards are based upon the learning theory of Constructivism (Chung, 2004). Constructivism is supported by cognitive theorists, such as Jean Piaget, Jerome Bruner, Zoltan Dienes, and Lev Vygotsky. Notably, Jean Piaget’s intellectual development (sensorimotor, preoperational, concrete operational, and formal operational) and Jerome Bruner’s learning modes (enactive, iconic, and symbolic) provide demonstrations of constructivism in school-age children. Constructivist ideology focuses on processes and the use of manipulatives. Students should be introduced to new concepts in three ways to accomplish representation: action (enactive), visual pictures (iconic), and through the use of words (symbolic). This is meant to help students transition from concrete to abstract levels of understanding.

Field Testing Reform Math: What the Research Shows at the Elementary Level

Carrol (1997), found that third grade students across 26 reform curriculum classrooms (as per use of the Everyday Math textbook) scored well above (64 points greater) the state median score on an Illinois State Mathematics Assessment. Moreover, 14 of achievement in the classes containing students who had been immersed in the Everyday Math curriculum since kindergarten was even higher, 75 points above the state score. This suggests a positive longitudinal effect of the curriculum. This is in accordance with other research (Mong & Mong, 2010) indicating that the social validity of an intervention may be affected by the time involved.

A flaw in Carrol’s study is that the author does not indicate what the SES of students in the “traditional classrooms” was in comparison to those in the reform classes. This might indeed be a confounding variable, because students in the traditional classrooms were all from Chicago- a place known to be plagued by poverty and high dropout rates.

Fuson, Carroll, & Drueck (2000), determined that Everyday Math 3rd graders outscored traditional U.S. students on place value and numeration, reasoning, geometry, data, and number-story items. The study is not completely reliable, however. Researchers were not able to match Everyday Math curriculum schools with comparable ones, and therefore chose to use data from existing studies to provide comparisons. Obviously, this is a weaker comparison than using fresh scores and evaluations.

Crawford and Snider (2000), conducted a two-year study conducted in two fourth grade classrooms investigated the effectiveness of two mathematics curricula. Results found that a reform program based on the text *Connecting* ***Math*** *Concepts*, resulted in significantly higher student scores on mathematics tests than the use of a **traditional math** basal textbook.

Considerations: While in this instance, the reform text used did yield higher scores, it is important to note that the specific book in question is not nearly as widespread across elementary schools as its reform counterpart, the ubiquitous text *Everyday Math*.

Field Testing Reform Curricula in Middle School and Beyond

There are a couple of studies that suggest reform math might be best implemented in the middle school grades and beyond, when math becomes more abstract and conceptually oriented. (Cai, Wang, Moyer, Wang, & Nie, (2011), determined that for algebra, the use of reform curriculum contributed significantly to problem-solving growth and students’ ability to represent problem situations. Similarly, in Texas, Vega (2011), found 9th grade ELLs, 9th grade economically disadvantaged students, and 11th grade African American students who were reform taught from 2003-2004 were significantly outperformed those traditionally taught.

**Traditional/Procedural Math Curricula**

Overview of Traditional Math Curricula

Traditionalists eschew the reform notion that students can not only construct their own understandings of mathematics, but also actually *reinvent* significant mathematics if given a chance (Frykholm, 2004) Cognitive ability as well as math fluency play an important role in mathematical skills. Understanding the relationship between cognitive abilities and mathematical skills is imperative to teaching effective arithmetic skills(Ramos-Christian & Schleser, 2008).

Traditionalists adhere to the belief that domain-specific mathematical problem-solving skills can be taught by emphasizing worked examples of problem-solution strategies. A worked example provides problem-solving steps and a solution for students. Direct, explicit instruction is vital in all curriculum areas, especially areas that many students find difficult and that are critical to modern societies. Mathematics is such a discipline. Minimal instructional guidance in mathematics leads to minimal learning. In short, traditionalists rely on research indicating that they can teach aspiring mathematicians to be effective problem solvers only by helping them memorize a large store of domain-specific schemas (Sweller, Clark, & Kirschner, 2010).

Traditional Instructional Methods

In a traditional framework, mathematical problem-solving skill is acquired through a large number of specific mathematical problem-solving strategies relevant to particular problems. Studying worked examples interleaved with practice solving the type of problem described in the example reduces unnecessary working-memory load that prevents the transfer of knowledge to long-term memory. The improvement in subsequent problem-solving performance after studying worked examples rather than solving problems is known as the worked-example effect. The didactic teaching world is highly ritualized and features procedures presented by teachers, with students practicing those procedures alone. For this reason, Son & Senk (2010), report multistep computational problems to be more common in traditional textbooks than in reform ones. Traditional textbooks also excel over reform pedagogies in providing more opportunities to practice number sense skills (Sood & Jitendra, 2007).

Traditional Theorists/Practitioners

Sandra Stotsky, Professor of Education Reform at the [University of Arkansas](http://en.wikipedia.org/wiki/University_of_Arkansas), is a staunch traditionalist. She, educated parents, and prominent mathematicians voice objections to the stress on calculator use in the early grades, the over-emphasis on student-developed algorithms at the expense of standard algorithms, and the de-emphasis at the high school level on computation in algebra and proof in Euclidean geometry (Stotsky, 2007). Countries like Singapore and Korea, which consistently outperform American students, also are proponents of traditional, rigorous curricula that focus on procedural knowledge and sound, well-known algorithms.

Field Testing Traditional Math: What the Research Shows at the Elementary Level

Three Research studies strongly indicate the efficacy of employing traditional texts. Hook, Bishp, & Hook (2007), established that students in California were shown to make statistically significant gains in math performance over five years of utilizing a text based on the six leading TIMMS math countries in Asia and Europe (which are highly traditionalist oriented). Agodini and Harris (2010), found that across 39 schools, first graders using the traditional text, Saxon Math, performed 0.30 SD higher than reform "Investigations" students and 0.24 SD higher than "SFAW" students. Finally, Poncy, McCallum, and Schmitt (2010), utilized an alternating treatments design to compare a traditionalist behavioral intervention, "Cover, Copy, and Compare" (CCC), to an intervention from a reform-oriented resource, "Facts That Last" (FTL). Results demonstrated that CCC led to increases in math-fact fluency, whereas the class-wide response to FTL activities did not differ from the control condition. Two months post-intervention, maintenance data revealed that the fluency increases associated with CCC were sustained.

Field Testing Traditional Curricula Abroad

In the Netherlands, Kroesbergen, Van Luit, and Maas (2004) compared the effects of smallgroup constructivistand explicit mathematics instruction in basic multiplication on low-achieving students' performance and motivation. A total of 265 students (aged 8-11 years) from 13 general and 11 special elementary schools for students with learning and/or behavior disorders participated in the study. The experimental groups received 30 minutes of reform or traditional instruction in groups of 5 students twice weekly for 5 months. Pre- and posttests were conducted to compare the effects on students' automaticity, problem-solving, strategy use, and motivation to the performance of a control group who followed the regular curriculum. Results showed that the math performance of students in the traditional instruction condition improved significantly more than that of students in the constructivist condition

**Assessment of Research**

Due to oversights in the studies regarding reform math efficacy (see above), my analysis leads me to conclude traditional methods of math instruction to be more valuable.

**Research Hypothesis**

At the end of the school year, two groups (~28 *n*) of fourth grade students will be tested in their proficiency in multiple digit multiplication and long division. In the control group, students who used the textbook *Everyday Math* will be gauged on the accuracy of their answers and average rate (time) of completion. A research group will consist of another class that utilized a book with traditional algorithms such as *SRA Real Math* or *Saxon Math*. Students who studied traditional algorithms are expected to yield higher scores and exhibit a shorter average amount of time for completion.

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